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| **US Radiocommunication Sector**  **FACT SHEET** | | | |
| **Study Group:** USWP 7B | | | **Document No:** US7B\_27\_019\_NC |
| **Reference:** Annex 11 to Document 7B/35-E | | | **Date:** 8 July 2024 |
| **Document Title:** Proposal of updates to Preliminary Draft New [Recommendation/Report] ITU-R SA.[2 GHz SOS CHAR], *Technical and operational characteristics of the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands to be used for assessing interference and for conducting sharing studies*. | | | |
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| **Purpose:** To propose modifications to PDN [Rep./Rec.] ITU-R SA.[2 GHz SOS CHAR] contained in Annex 11 of Document 7B/35-E. | | | |
| **Abstract:** PDNR ITU-R SA.[2 GHz SOS CHAR] provides technical and operational characteristics to be used in sharing studies for the space operation service (SOS) that use the 2025-2110 MHz (Earth-to-space) (space-to-space) and 2200-2290 MHz (space-to-Earth) (space-to-space) frequency bands. Table 5 of PDNR ITU-R SA.[2 GHz SOS CHAR] requires updates to parameters characterizing Systems K, L, M, and N. Additionally, updates are required to maintain consistency in the derivation of values between the different systems. For example, the reference point to derive the ‘satellite antenna input power’ for various systems in Table 5 is not consistent. This contribution proposes the modifications to parameters in the PDNR. | | | |
| **Fact Sheet Preparer:** Botan Karim, NOAA | | | |

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| **Radiocommunication Study Groups** |  |
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| Proposed REVISIONS TO Preliminary draft new [Report/Recommendation] ITU-R SA.[2 GHz SOS CHAR] | |
|  | |

This input contribution includes proposed revisions (highlighted in blue) to the most recent version of the Preliminary Draft New [Report/Recommendation] ITU-R SA.[2 GHz SOS CHAR], as contained in Annex 11 of the Working Party 7B Chair’s Report (Document [7B/35-E](https://www.itu.int/md/R23-WP7B-C-0035/en)). The document includes technical and operational characteristics of the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands to be used for assessing interference and for conducting sharing studies.

The proposal includes revisions to the non-GSO SOS system parameters in Tables 5, 6, and 8. For example, the values of the “satellite antenna input power” for Systems K, L, M, N, and P now include the feeder losses, and system identifiers have been clarified.

**Attachment:** 1

|  |
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| ATTACHMENT |
| PRELIMINARY DRAFT NEW [REPORT/RECOMMENDATION]  ITU-R SA.[2 GHZ SOS CHAR] |
| Technical and operational characteristics of the space operation service (SOS) systems that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands to be  used for assessing interference and for conducting sharing studies |

(20XX)

[Editor’s Note 1: This document was initiated at the April 2021 Working Party (WP) 7B meeting and further modified at April 2022, October 2023 and March 2024 meetings. It was proposed in the form of a Recommendation. Other possible options were also discussed such as a Report or of an update of an existing Recommendation or Report. If the final form of the document is to provide limited number of typical characteristics, then it could deserve being a Recommendation. On the contrary, if it includes a number of different systems with large variety of parameters, a Report would probably be a better solution. It was not concluded, the meeting agreeing that the more important issue at current stage is to focus in the Annex and the data provided. Administrations and members are encouraged to contribute at next WP 7B meetings to help progressing this issue further, also providing their views on the scope of this document]

**Scope**

This [Report/Recommendation] provides technical and operational characteristics to be used in sharing studies for the space operation service (SOS) that use the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands [related to science missions].

Keywords

Tracking, Telemetry, Command, Space Operation, TT&C, SOS, DRS, POCS

Related ITU-R Recommendations and Reports

Recommendation [ITU-R SA.3](https://www.itu.int/rec/R-REC-SA.363)63 – *Space operation systems*

Recommendation [ITU-R SA.1018](https://www.itu.int/rec/R-REC-SA.1018) – *Hypothetical reference system for systems comprising data relay satellites in the geostationary orbit and user spacecraft in low Earth-orbits*

Recommendation [ITU-R SA.1020](https://www.itu.int/rec/R-REC-SA.1020) – *Hypothetical reference system for the Earth exploration-satellite and meteorological satellite services*

Recommendation [ITU-R SA.1414](https://www.itu.int/rec/R-REC-SA.1414) – *Characteristics of data relay satellite systems*

[The ITU Radiocommunication Assembly,

considering

*a)* that the frequency band 2 025-2 110 MHz is allocated to the SOS on a primary basis among other services in the Earth-to-space and space-to-space directions;

*b)* that the frequency band 2 200-2 290 MHz is allocated to the SOS on a primary basis among other services in the space-to-Earth and space-to-space directions;

*c)* that in order to carry out sharing studies, technical and operational characteristics of space operation service systems for use in the frequency bands 2 025-2 110 MHz and 2 200‑2 290 MHz are needed,

recommends

that the technical and operational system characteristics for the space operation service operating in the 2 025-2 110 MHz (Earth-to-space) (space-to-space) and 2 200-2 290 MHz (space-to-Earth) (space-to-space) frequency bands detailed in the Annex should be used in sharing studies.]

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# 1 Introduction

This Report/Recommendation] provides the technical and operational characteristics of the three major tasks that the telemetry, tracking and command (TT&C) systems perform to ensure the successful operation of a satellite:

1 Telemetry to enable ground controllers to monitor the operational health and status of the satellite, and the measured values are transmitted from satellite to the ground control centre.

2 Tracking/ranging to enable ground controllers to determine the satellite’s location and orientation.

3 Telecommand to enable ground controllers to command the various electronic units aboard the satellite, sending commands from the ground to the satellite.

The frequency band 2 025-2 110 MHz is allocated to space operation service (SOS) (Earth-to-space) (space-to-space) and the frequency band 2 200-2 290 MHz is allocated to SOS (space-to-Earth) (space-to-space). These frequency bands are used by both, geostationary and non-geostationary satellites, and the data relay satellites as well. Typical characteristics for systems in these frequency bands are listed below in Tables 1 through 13.

# 2 Technical and operational characteristics of the Geostationary satellites

## 2.1 Telemetry in 2 200-2 290 MHz frequency band

Table 1 lists the system parameters of telemetry downlinks in the frequency band 2 200-2 290 MHz for the geostationary (GSO) SOS systems.

TABLE 1

GSO SOS system parameters for telemetry downlinks in the frequency band 2 200-2 290 MHz

| Function | Units | Telemetry |
| --- | --- | --- |
| **System** |  | **System A** |
| Necessary bandwidth | MHz | 4.930 |
| Satellite parameters | | |
| Satellite antenna input power | dBW | 1.8 |
| Satellite antenna type |  | Helix |
| Satellite maximum antenna gain | dBi | 3.0 |
| Satellite antenna polarization |  | RHCP |
| Satellite antenna radiation diagram |  | Cardioid −13 dB @ 170 degrees |
| **Earth station parameters** | | |
| Earth station antenna type |  | Parabolic |
| Earth station antenna radiation pattern |  | Rec. ITU-R S.465-5 |
| Earth station antenna gain toward satellite | dBi | 49.8 |
| Earth station antenna polarization |  | RHCP |
| Earth station receiver noise temperature | K | 115 |
| Elevation angle of earth station antenna towards the satellite | Degree | 5 |
| Note: RHCP – Right-hand circular polarization | | |

## 2.2 Tracking/ranging in 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands

Ranging is required by GSO satellites in order to keep the spacecraft within range of its operational orbital location. Ranging is accomplished by transmitting a tone from the earth station and having the spacecraft retransmit that tone back to the earth station. Table 2 lists the parameters for ranging links in the 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands for GSO SOS systems.

TABLE 2

GSO SOS system parameters for ranging links in the 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands

|  |  |  |  |
| --- | --- | --- | --- |
| Function | Units | Tracking/ranging | |
| **System** |  | **System B** | **System C** |
| Necessary bandwidth | MHz | 1.45 | 2.0 |
| **Satellite parameters** | | | |
| Satellite antenna input power | dBW | 1.8 | 7 |
| Satellite antenna type |  | Crossed Dipoles | Omni |
| Satellite maximum antenna gain | dBi | 4.0 | 1.0 |
| Satellite antenna polarization |  | RHCP | RHCP |
| Satellite antenna radiation diagram |  | Cardioid  −11 dB @ 165 degrees | Omni |
| Satellite receiver noise temperature | K | 920 | 3 000 |
| **Earth station parameters** | | | |
| Earth station antenna input power | dBW | 21.9 | 30 |
| Earth station antenna type |  | Parabolic | Parabolic |
| Earth station antenna radiation pattern |  | First sidelobe 34.8 dB at 0.9 degrees | Beamwidth = 0.55 degrees plus Rec. ITU-R S.465-5 |
| Earth station antenna gain toward satellite | dBi | 49.8 | 50 |
| Earth station antenna polarization |  | RHCP | RHCP |
| Earth station receiver noise temperature | K | 115 | 100 |
| Elevation angle of earth station antenna towards the satellite | deg | 5 | 5 |

## 2.3 Command in the 2 025-2 110 MHz frequency band

Table 3 lists the parameters for command links in the 2 025-2 110 MHz frequency band for GSO SOS systems.

TABLE 3

GSO SOS system parameters for command uplinks in the frequency band 2 025-2 110 MHz

| Function | Units | Command | |
| --- | --- | --- | --- |
| **System** |  | **System D** | **System E** |
| Necessary bandwidth | MHz | 0.084 | 0.128 |
| **Earth station parameters** | | | |
| Earth station antenna input power | dBW | 21.9 | 17 |
| Earth station antenna type |  | Parabolic | Parabolic |
| Earth station antenna radiation pattern |  | 34.6 dB @ 0.95 degrees  Rec. ITU-R S.465-5 | Beamwidth = 0.59 degrees plus  Rec. ITU-R S.465-5 |
| Earth station antenna gain toward satellite | dBi | 49.6 | 49.5 |
| Earth station antenna polarization |  | RHCP | RHCP |
| **Satellite parameters** | | | |
| Satellite antenna type |  | Omni | Omni |
| Satellite maximum antenna gain | dBi | 4.0 | 1.0 |
| Satellite antenna polarization |  | RHCP | RHCP |
| Satellite antenna radiation diagram |  | −11 dB @ 165 degrees | Omni |
| Satellite receiver noise temperature | K | 920 | 3 000 |
| Elevation angle of earth station antenna towards the satellite | deg | 5 | 5 |

# 3 Technical and operational characteristics of the Non-geostationary satellites

Typical non-GSO orbital parameters for use in sharing studies:

TABLE 4

Examples of non-GSO SOS orbital parameters (LEO)

| Function | Units | Value | Value | Value |
| --- | --- | --- | --- | --- |
| **System** |  | **Example 1** | **Example 2** | **Example 3** |
| Shape of orbit |  | Circular | Nearly circular; sun synchronous | Circular, sun synchronous |
| Orbital altitude | km | 800 | Varying between 592 km and 612 km | 628 |
| Inclination angle | deg | 98 | 97.74 | 97.9 |
| Eccentricity |  | 0 | 0.02 | 0 |
| Longitude of ascending node | deg | 0 |  |  |
| Local Time of the Ascending/Descending Node | Hours |  | 18:00/06:00  or 22:00/10:00  or 24:00/12:00 | 24:00/12:00 |
| … | … | … |  |  |

TABLE x

Examples of non-GSO SOS orbital parameters (MEO, other orbits)

| Function | Units | Value |
| --- | --- | --- |
| **System** |  | **Example 1** |
| Shape of orbit |  | elliptical |
| Orbital altitude | km | 40 000 (apogee)  3 000 (perigee) |
| Inclination angle | deg | 30 |
| Eccentricity |  |  |
| Longitude of ascending node | deg |  |
| Local Time of the Ascending/Descending Node | Hours |  |
| … | … |  |

[Editor’s note: In this table, information of various orbits such as MEO (including elliptical orbit), Lagrange orbits should be included.]

## 3.1 Telemetry in the 2 200-2 290 MHz frequency band

Table 5 lists the system parameters of telemetry downlinks in the frequency band 2 200-2 290 MHz for the non-geostationary (non-GSO) SOS systems.

TABLE 5

Non-GSO SOS system parameters for telemetry downlinks in the frequency band 2 200-2 290 MHz

| Function | Units | Contingency and Launch | Telemetry | | | | | |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **System** |  | **System K** | **System L** | **System M** | **System N** | **System X** | **System Y** | **System Z** | **System AA** |
| Necessary bandwidth | MHz | 4.55 | 6.04 | 0.064 | 1.15 | 0.69 / 2.5 | 0.8 | 3 | 3.32 |
| Minimum elevation angle | deg | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Satellite parameters** | | | | | | |  |  |  |
| Satellite antenna input power \*1 | dBW | 6.0 | 5.6 | -12.0 | 5.0 | ‒22.2 / −5.2 | -3 | 7 | 3 |
| Satellite antenna type |  | Omni | Helix |  | 2 omni antennas | Crossed dipoles with a reflector | Omni | Omni | Broadband patch panel |
| Satellite maximum antenna gain | dBi | 4.6 | 7.3 | 2.5 | -4.5 | 7.5 | -5.5 | 3 | 5.6 |
| Satellite antenna polarization |  | LHCP/RHCP | RHCP | RHCP | LHCP | RHCP | RHCP | RHCP | RCHP |
| Satellite antenna radiation diagram \*2 |  | ND | ND | ND | ND | Non-directional by installing multiple antenna | ND | ND | ND |
| **Earth station parameters** | | | | | | |  |  |  |
| Earth station antenna type |  | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic |
| Earth station antenna radiation pattern |  | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 | RR App. **8** | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 |
| Earth station antenna gain toward satellite | dBi | 51 | 42 / 44.8 / 46.8 | 34.2 / 46.6 | 50.5 / 51.8 | 44.2 | 42 / 45 / 47 | 42 / 45 / 47 | 42 / 45 / 47 |
| Earth station antenna polarization |  | LHCP/RHCP | RHCP | RHCP | LHCP | RHCP | RHCP | RHCP | RHCP |
| Earth station receiver noise temperature | K | 110 | 130 / 190 / 245 | 70 / 157 | 251 | 148 | 139 / 145 / 152 | 139 / 145 / 152 | 139 / 145 / 152 |
| Note: LHCP – Left-hand circular polarization; RHCP – Right-hand circular polarization | | | | | |  |  |  |  |

[Editor’s Note:

\*1: It should be checked whether the values of the “satellite antenna input power” include the antenna feeder loss.

\*2: “Satellite antenna radiation diagram” should be described more specifically.]

[US Note: It remains necessary to verify whether the feeder losses are also included in the satellite antenna input power values for Systems Y, Z, and AA.]

[US Note: This document should be reviewed for duplicate systems. For example, System K of Table 5 is the same system as System S in Table 8. These entries should have one system name. Additionally, there are 2 entries for System Y. The first entry for System Y was originally labelled System X, as observed in Document 7B/5-E. Lastly, it should be confirmed that System AA in Table 5 is the same system as System AA in Table 7.]

## 3.2 Ranging in the 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands

Ranging is used on non-geostationary satellites to locate the satellite’s position. Table 6 lists the parameters for ranging uplinks in the 2 025-2 110 MHz frequency band for non-GSO SOS systems.

Table 6

Non-GSO SOS System parameters for ranging uplinks in the frequency band 2 025-2 110 MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function | Units | Ranging Uplink | | |
| **System** |  | **System N** | **System P** | **System Z** |
| Necessary bandwidth | MHz | 1.0 | 0.095 | 1.1 |
| Minimum elevation angle | deg | 5 | 0 | 5 |
| Earth station antenna input power | dBW | 22.8 / 31 | 8 | 20 |
| **Satellite antenna parameters** | | | | |
| Satellite antenna type |  | 2 omni antennas | Omni | Crossed dipoles with a reflector |
| Satellite maximum antenna gain | dBi | -4.5 | 5.2 | 7.5 |
| Satellite antenna polarization |  | RHCP | RHCP | RHCP |
| Satellite antenna radiation diagram \*2 |  | ND | ND | Non-directional by installing multiple antenna |
| Space station receiver noise temperature | K | 1150 | 170 | 515 |
| **Earth station antenna parameters** | | | | |
| Earth station antenna type |  | Parabolic | Omni | Parabolic |
| Earth station antenna radiation pattern |  | RR App. **8** | ND | Rec. ITU-R S.465 |
| Earth station antenna gain toward satellite | dBi | 49.8 / 51.1 | 6 | 43.2 |
| Earth station antenna polarization |  | LHCP | Linear | RHCP |

[Editor’s Note:

\*1: It should be checked whether the values of the “satellite antenna input power” include the antenna feeder loss.

\*2: “Satellite antenna radiation diagram” should be described more specifically.]

Table 7 lists the parameters for ranging downlinks in the 2 200-2 290 MHz frequency band for non‑GSO SOS systems.

TABLE 7

Non-GSO SOS system parameters for ranging downlinks in the frequency band 2 200-2 290 MHz

| Function | Units | Ranging Downlink | | |
| --- | --- | --- | --- | --- |
| **System** |  | **System Q** | **System R** | **System AA** |
| Necessary bandwidth | MHz | 6 | 1.0 | 2.2 |
| Minimum elevation angle | deg | 5 | NA | 5 |
| **Satellite antenna parameters** | | | | |
| Satellite antenna input power \*1 | dBW | −0.2 |  | ‒22.2 |
| Satellite Antenna Type |  |  |  | Crossed dipoles with a reflector |
| Satellite maximum antenna gain | dBi | 2 | 24.0 | 7.5 |
| Satellite antenna polarization |  | RHCP | LHCP | RHCP |
| Satellite antenna radiation diagram \*2 |  |  |  | Non-directional by installing multiple antenna |
| **Earth station parameters** | | | | |
| Earth station antenna type |  | Parabolic | Parabolic | Parabolic |
| Earth station antenna radiation pattern |  | Rec. ITU-R S.465 | RR App. **8** | Rec. ITU-R S.465 |
| Earth station antenna gain toward satellite | dBi | 34.9/39 | 48.8 | 44.2 |
| Earth station antenna polarization |  | RHCP | LHCP | RHCP |
| Earth station receiver noise temperature | K | 75/100 | 170 | 148 |

[Editor’s Note:

\*1: It should be checked whether the values of the “satellite antenna input power” include the antenna feeder loss.

\*2: “Satellite antenna radiation diagram” should be described more specifically.]

## 3.3 Command in the 2 025-2 110 MHz range

Table 8 lists the parameters for command links in the 2 025-2 110 MHz frequency band for non‑GSO SOS systems.

TABLE 8

Non-GSO SOS system parameters for command uplinks in the frequency band 2 025-2 110 MHz

| Function | Units | Command | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| System |  | System K | System L | System M | System N | System W | System AB | System Y | System Z | System AA |
| Necessary bandwidth | MHz | 2.0 | Command 0.004  Configuration Data 0.256 | 0.064 | 0.036 | 6 | 0.50 / 1.1 | 0.38 | 0.3 | 0.2 |
| Minimum elevation angle | deg | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Earth station parameters** | | | | | | | |  |  |  |
| Earth station antenna input power | dBW | 28 | 18 | 11 | 22.8 / 31 | 22 | 20 | 11.7 | 11.7 | 11.7 |
| Earth station antenna type |  | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic | Parabolic |
| Earth station antenna radiation pattern |  | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | Rec. ITU-R S.465-6 | RR App. **8** | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 | Rec. ITU-R S.465 |
| Earth station antenna gain toward satellite | dBi | 43.5 / 47 | 41.4 / 42 / 44 / 46.2 | 36.5 / 46.8 | 49.8 / 51.1 | 34.2/38 | 43.2 | 41 / 44 / 46 | 41 / 44 / 46 | 41 / 44 / 46 |
| Earth station antenna polarization |  | LHCP/RHCP | RHCP | RHCP | LHCP | RHCP | RHCP | RHCP | RHCP | RHCP |
| **Satellite parameters** | | | | | | | |  |  |  |
| Satellite antenna type |  | Helix | Omni |  | 2 omni antennas |  | Crossed dipoles with a reflector | Omni | Omni | Omni |
| Satellite maximum antenna gain | dBi | 4.6 | 4 | 2.5 | -4.5 | 2 | 7.5 | 3.5 | 3 | 6.2 |
| Satellite antenna polarization |  | LHCP/RHCP | RHCP |  | RHCP | RHCP | RHCP | RHCP | RHCP | RHCP |
| Satellite antenna radiation diagram \*2 |  | ND | ND | ND | ND | ND | Non-directional by installing multiple antenna | ND | ND | ND |
| Satellite receiver noise temperature | K | 870 | 263 | 1697 | 603 | 450 | 515 | 999 | 1892 | 8300 |

[Editor’s Note:

\*1: It should be checked whether the values of the “satellite antenna input power” include the antenna feeder loss.

\*2: “Satellite antenna radiation diagram” should be described more specifically.]

# 4 Technical and operational characteristics of the SOS space-to-space links

The SOS space-to-space links typically include the use of a Data Relay Satellite (DRS) system and a Proximity Operations Communication System (POCS).

## 4.1 Data Relay Satellite (DRS) systems

The hypothetical reference system of the DRS systems is described in Recommendations ITU-R SA.1018 and ITU-R SA.1020. DRS spacecraft is typically located on the geostationary orbit, and the space-to-space links of the DRS system are established between the DRS spacecraft and low-Earth orbiting user spacecraft.

The 2 025-2 110 MHz frequency band is used for SOS Earth-to-space links. This frequency band is also used for SOS forward space-to-space links, typically for radiocommunications from DRS spacecraft to low-Earth orbiting spacecraft. The characteristics of DRS-to-spacecraft links can be found in Table 2 of Recommendation ITU-R SA.1414.

The 2 200-2 290 MHz frequency band is used for SOS space-to-Earth links. This frequency band is also used for SOS return space-to-space links, typically for radiocommunications from low-Earth orbiting spacecraft to DRS spacecraft. The characteristics of spacecraft-to-DRS links can be found in Table 3 of Recommendation ITU-R SA.1414.

## 4.2 Proximity Operations Communication System (POCS)

The proximity space links are short-range, bi-directional, fixed or mobile radio links, generally used to communicate among probes, landers, rovers, orbiting constellations, and orbiting relays. The Proximity Operations Communication system (POCS) supports several communications needs between such a variety of network elements for manned and unmanned missions.

The 2 025-2 110 MHz frequency band is used for the POCS forward space-to-space radiocommunications links and the 2 200-2 290 MHz frequency band is used for the POCS return space-to-space radiocommunications links.

Typical POCS operations scenarios are as follows.

TABLE 9

Examples of POCS operations scenarios

| **System** | **Example 1** |
| --- | --- |
| Location to operate | Near-Earth circular orbit of about 400 km altitude |
| Communication system 1 | Visiting spacecraft |
| Communication system 2 | Manned spacecraft |
| Objectives of operations | Inter-orbit communication when visiting spacecraft approaches manned spacecraft |
| Maximum distance between POCS systems | 23 km |

### 4.2.1 Telemetry in the 2 200-2 290 MHz frequency band

Table 10 lists the system parameters of telemetry return links in the frequency band 2 200-2 290 MHz for both transmitting and receiving sides of the POCS systems.

TABLE 10

POCS system parameters for telemetry return links in the frequency band 2 200-2 290 MHz

| Function | Units | Telemetry |
| --- | --- | --- |
| **System** |  | **System AC** |
| Necessary bandwidth | MHz | 6 |
| Communication **system 1 parameters (transmitting side)** | | |
| antenna input power | dBW | ‒0.02 |
| antenna type |  | Helix |
| maximum antenna gain | dBi | 5 |
| antenna polarization |  | RHCP |
| antenna radiation diagram |  | Non-directional by installing multiple antenna |
| Communication **system 2 parameters (receiving side)** | | |
| antenna type |  | Micro-strip |
| antenna radiation pattern |  | Non-directional by installing multiple antenna |
| antenna gain | dBi | 7.5 |
| antenna polarization |  | RHCP |
| receiver noise temperature | K | 525 |
| Note: LHCP – Left-hand circular polarization; RHCP – Right-hand circular polarization | | |

### 4.2.2 Ranging in the 2 025-2 110 MHz and 2 200-2 290 MHz frequency bands

Ranging is used on the POCS links to measure distance between two POCS systems. Table 11 lists the parameters for ranging forward links in the 2 025-2 110 MHz frequency band for both transmitting and receiving sides of the POCS systems.

Table 11

POCS system parameters for ranging forward links in the frequency band 2 025-2 110 MHz

| Function | Units | Ranging Forward |
| --- | --- | --- |
| **System** |  | **System AD** |
| Necessary bandwidth | MHz | 10 |
| Communication **system 1 antenna parameters (transmitting side)** | | |
| antenna input power | dBW | ‒7.6 |
| antenna type |  | Micro-strip |
| maximum antenna gain | dBi | 7.5 |
| antenna polarization |  | RHCP |
| antenna radiation diagram |  | Non-directional by installing multiple antenna |
| Communication **system 2 antenna parameters (receiving side)** | | |
| antenna type |  | Helix |
| antenna radiation pattern |  | Non-directional by installing multiple antenna |
| antenna gain | dBi | 5.0 |
| antenna polarization |  | RHCP |
| receiver noise temperature | K | 455 |

Table 12 lists the parameters for ranging return links in the 2 200-2 290 MHz frequency band for both transmitting and receiving sides of the POCS systems.

TABLE 12

POCS system parameters for ranging return link in the frequency band 2 200-2 290 MHz

| Function | Units | Ranging Return link |
| --- | --- | --- |
| **System** |  | **System AE** |
| Necessary bandwidth | MHz | 6 |
| Communication **system 2 antenna parameters (transmitting side)** | | |
| antenna input power | dBW | ‒0.02 |
| Antenna Type |  | Helix |
| maximum antenna gain | dBi | 5.0 |
| antenna polarization |  | RHCP |
| antenna radiation diagram |  | Non-directional by installing multiple antenna |
| Communication **system 1 parameters (receiving side)** | | |
| antenna type |  | Micro-strip |
| antenna radiation pattern |  | Non-directional by installing multiple antenna |
| antenna gain | dBi | 7.5 |
| antenna polarization |  | RHCP |
| receiver noise temperature | K | 525 |

### 4.2.3 Command in the 2 025-2 110 MHz range

Table 13 lists the parameters for command links in the 2 025-2 110 MHz frequency band for both transmitting and receiving sides of the POCS systems.

TABLE 13

POCS system parameters for command forward links in the frequency band 2 025-2 110 MHz

| Function | Units | Command |
| --- | --- | --- |
| **System** |  | **System AF** |
| Necessary bandwidth | MHz | 10 |
| Communication **system 2 parameters (transmitting side)** | | |
| antenna input power | dBW | ‒7.6 |
| antenna type |  | Micro-strip |
| antenna radiation pattern |  | Non-directional by installing multiple antenna |
| antenna gain toward | dBi | 7.5 |
| antenna polarization |  | RHCP |
| Communication **system 1 parameters (receiving side)** | | |
| antenna type |  | Helix |
| maximum antenna gain | dBi | 5.0 |
| antenna polarization |  | RHCP |
| antenna radiation diagram |  | Non-directional by installing multiple antenna |
| receiver noise temperature | K | 455 |